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# Optical inspection status

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DESY

TTC Meeting 2010

19.04.2010      FNAL

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Many thanks to:

R. Geng (JLab)  
D. Sergatskov (FNAL) and  
K. Watanabe (KEK)

for providing input to this talk!

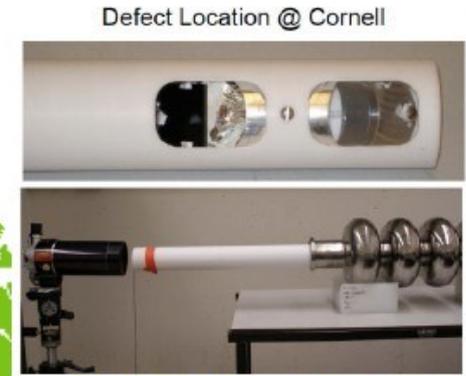
# Optical inspection around the world



DESY : Kyoto Camera



FNAL : Kyoto Camera,  
Questar long-distance microscope

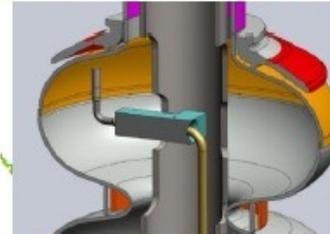


Cornell : Inspection  
system

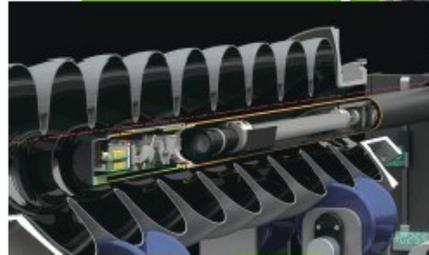
KEK (STF) : Kyoto



LosAlamos: Karl Storz videoscope



J-Lab : Lab cavity  
inspection tool based on  
long-distance microscope,  
Kyoto Camera



High resolution camera system is generally used at many labs around the world for 1.3 GHz 9-cell cavities to understand the field limitation.

Original: K.Watanabe, SRF09  
Updated: Y. Yamamoto, LCWS&ILC10



# Inspection of 2-cell cavities at KEK

Proto-type model (fabrication in 2008)

ERL injector 2-cell cavity **#1** (KEK, made by MHI)

Four HOM coupler equipped beam pipe for strong damping.  
(Two antenna type and two loop type HOM couplers)

1<sup>st</sup> V.T. with HOM pickup probe was done in April 2009.  
(See TTC meeting in Orsay, June 2009)

2<sup>nd</sup> V.T. without HOM pickup probe was done in Feb 2010.



Proto-type model (fabrication at 2009)

ERL injector 2-cell cavity **#2** (KEK, made by MHI)

Five loop-type HOM coupler equipped beam pipe to obtain stronger damping for monopole modes.

1<sup>st</sup> V.T. without HOM pickup probe was done Mar 2010.

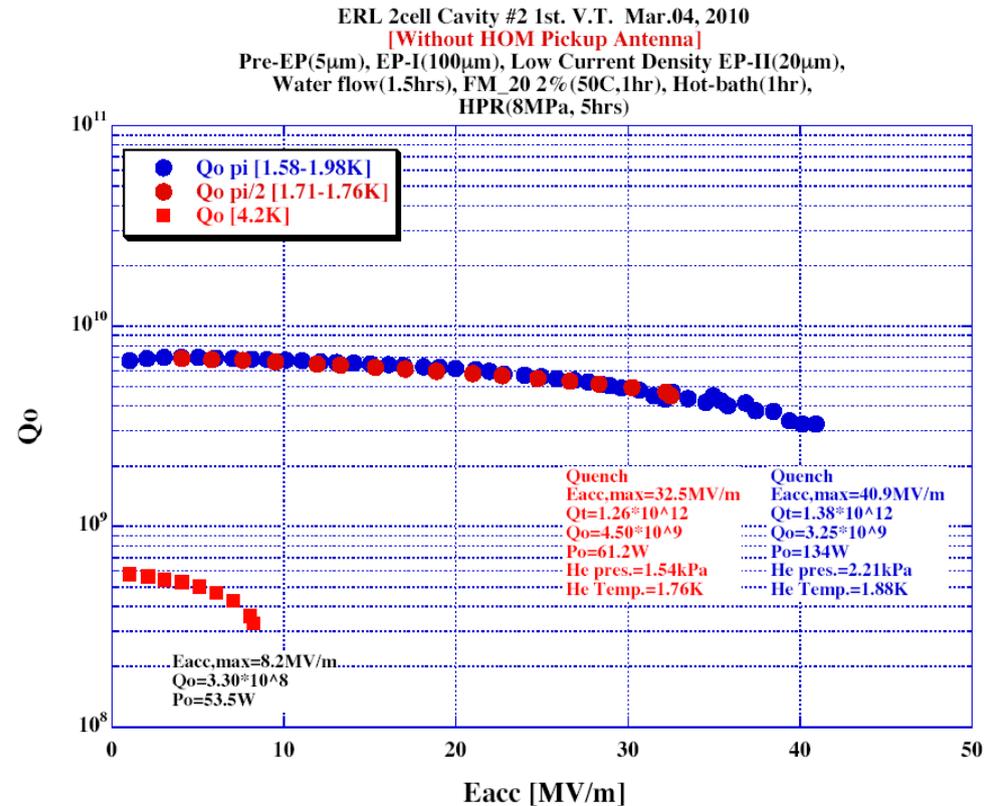
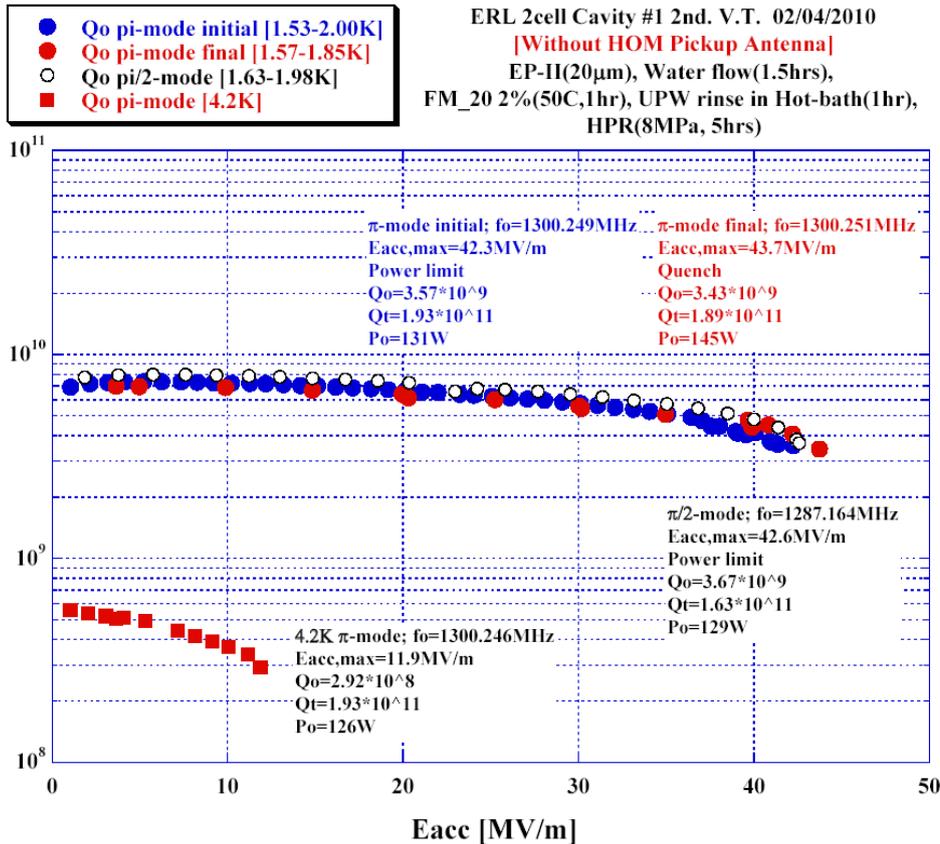
2<sup>nd</sup> V.T. with HOM pickup probe will be done April 2010.



Two step test for both cavities: (1) Without HOM pickup probe, (2) With HOM pickup probe.

To estimate the cavity performance (EBW) and the HOM coupler performance (RF design).

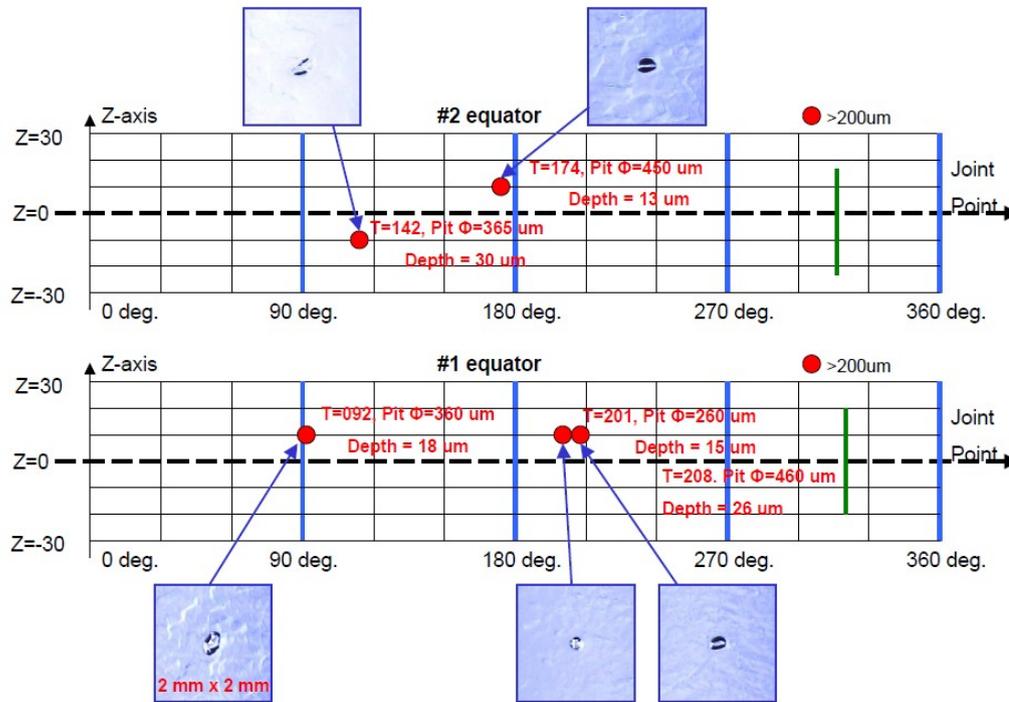
# Vertical test without HOM pick-up



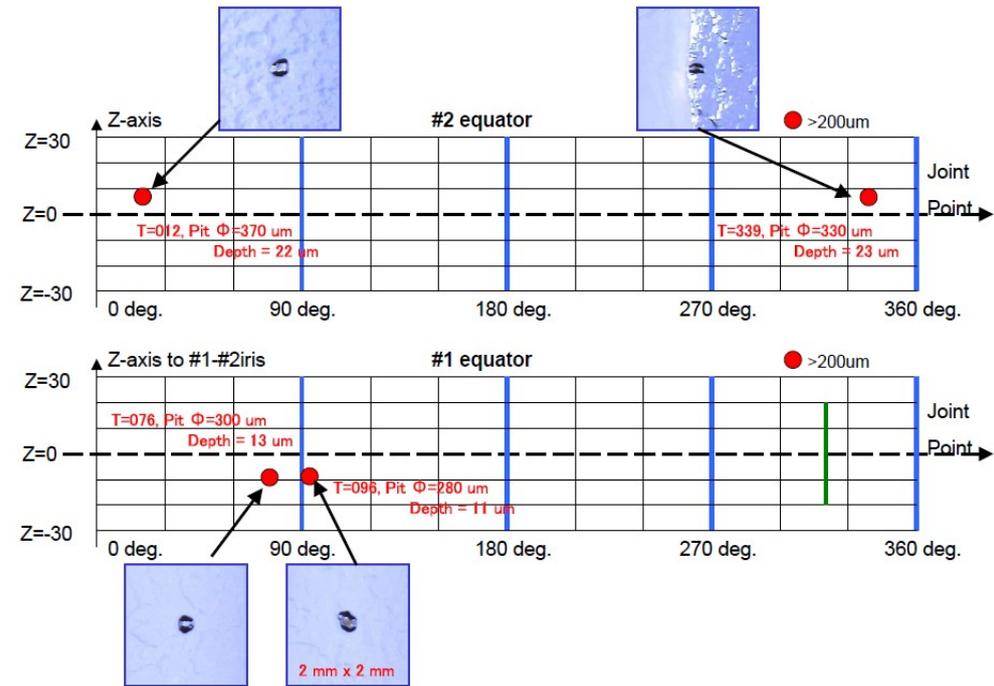
- Two ERL injector 2-cell cavities achieved Eacc = 43.7 MV/m (#1) and Eacc = 40.9 MV/m (#2) without HOM pickup probe.

# Inspection after vertical test

ERL injector 2-cell cavity #1

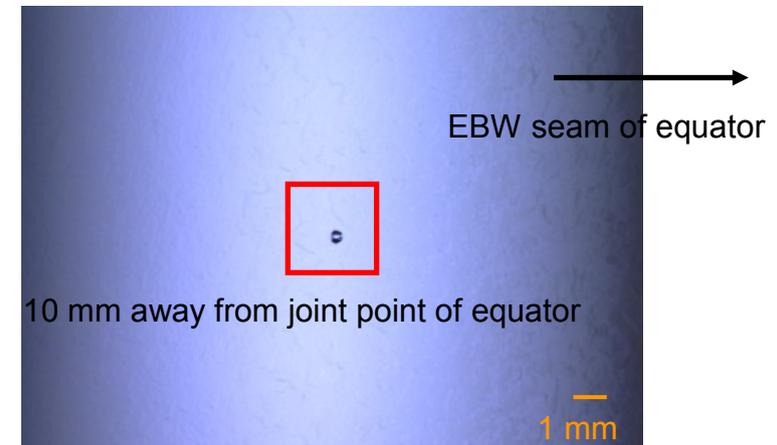


ERL injector 2-cell cavity #2

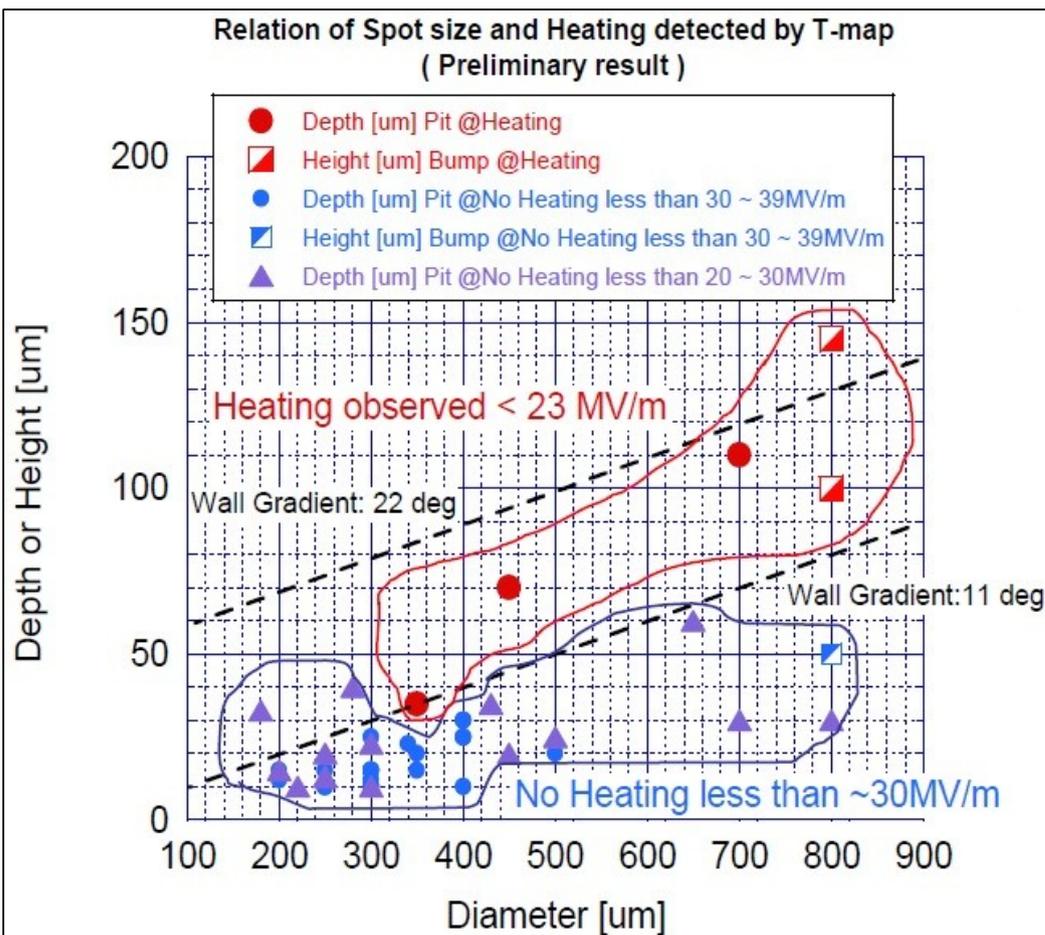


Both cavities have the suspicious spots outside the weld area.  
 But: these spots did not heat up to  $E_{acc} = 41 \sim 43 \text{ MV/m}$ .

Example : #2 cavity, 1-cell equator, outside weld area,  $t=076\text{deg}$ .

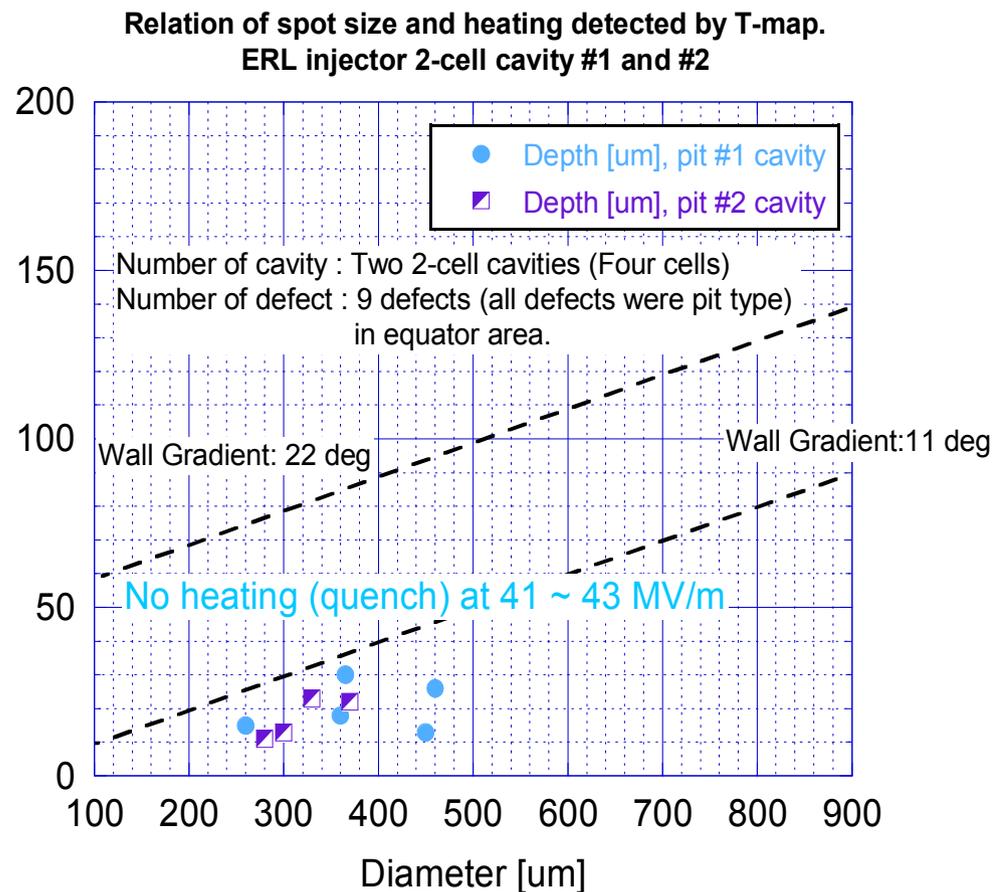


# Correlation of geometrical spot size and heating (rough estimation)



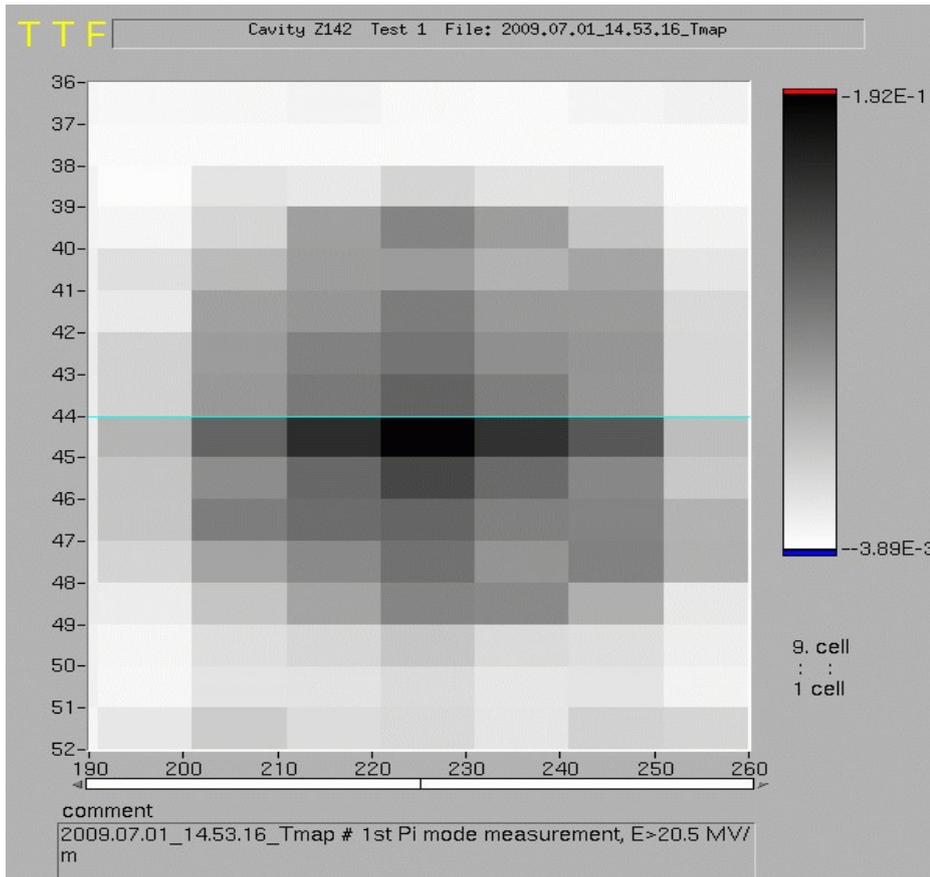
Sample: MHI-01 ~ MHI-09, AES-01 : 10 cavities.  
Number of cell = 90 cells, Number of detected spot = 49 spots.

K.Watanabe, SRF09



The information of geometrical spot size and the field was updated.

# Tmap $\leftrightarrow$ Opt. Inspection: Z142

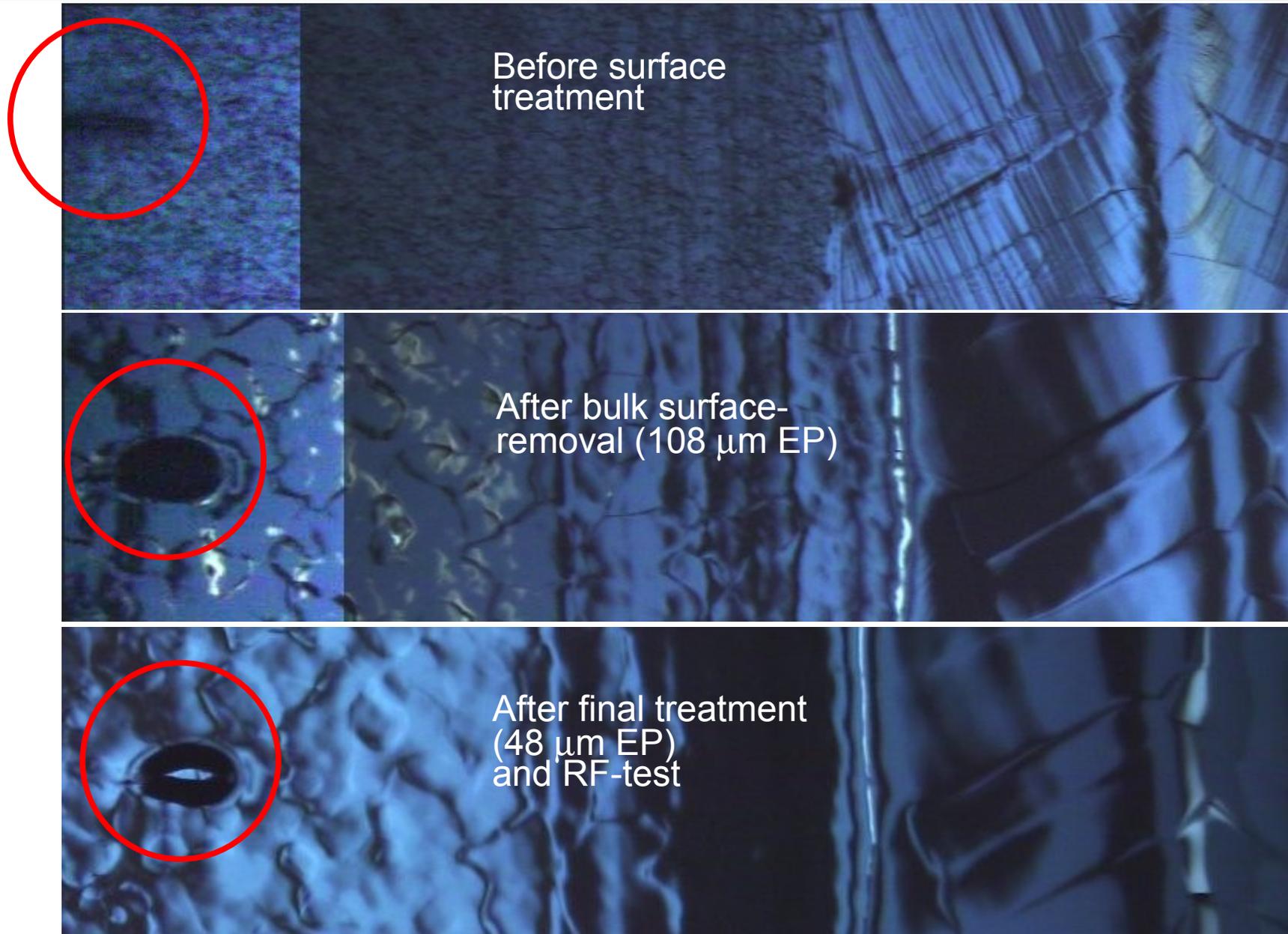


Hotspot during T-map  
at equator 6 in  $\pi$ -mode,  
Limited by quench  
at 20.6 MV/m

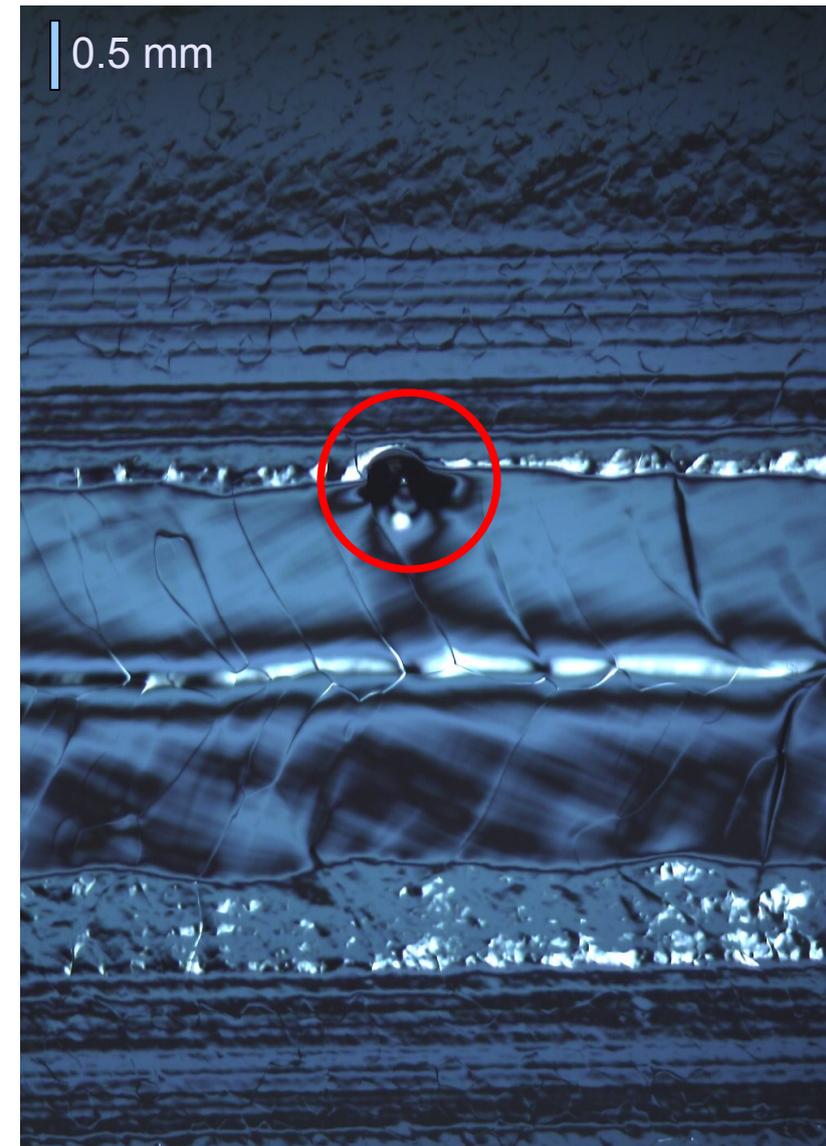
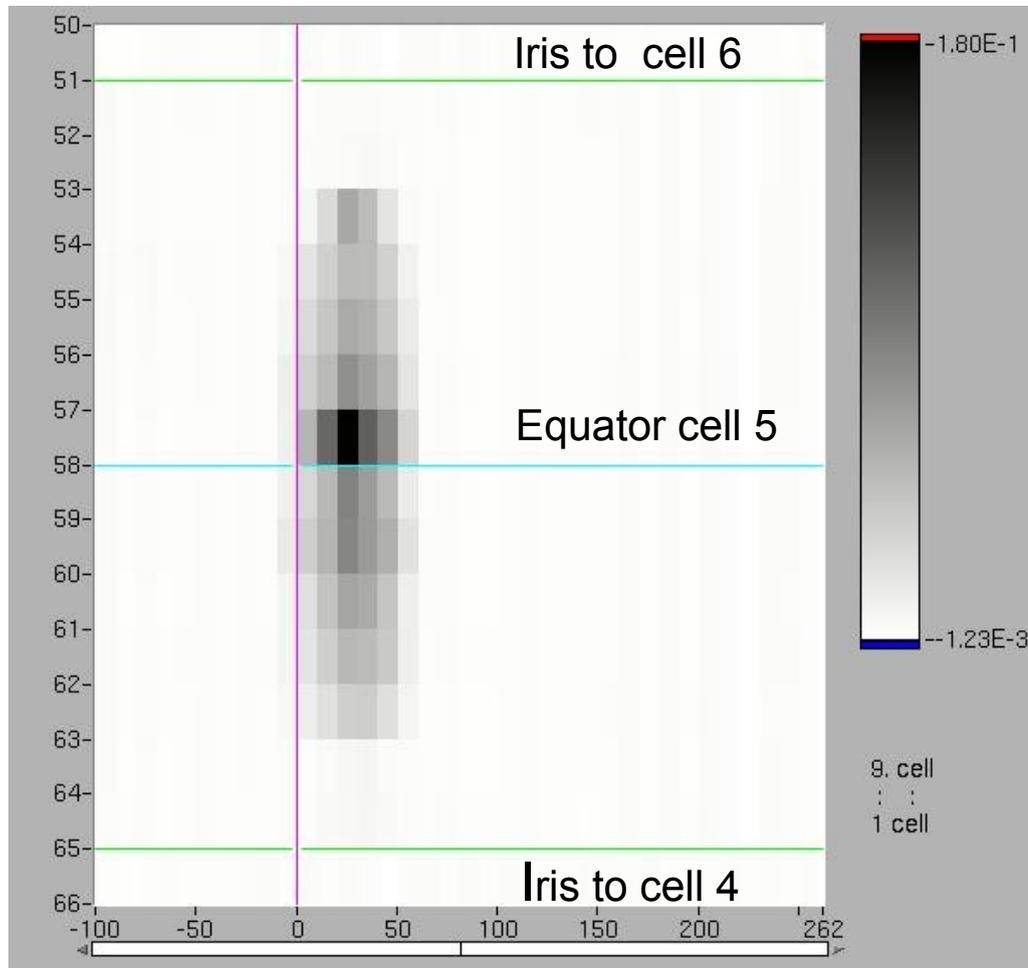


Same region inside cavity after  
RF-test

# Evolution of defect in Z142



# Comparison: Tmap $\leftrightarrow$ opt. inspection

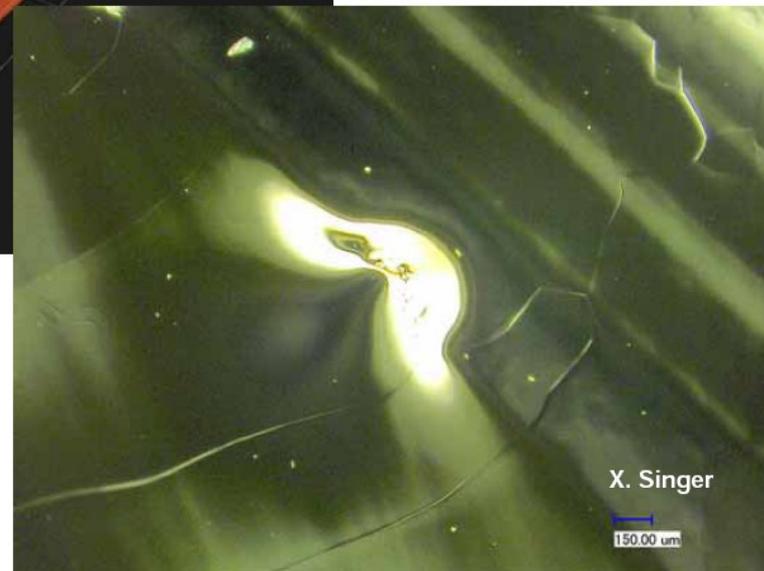
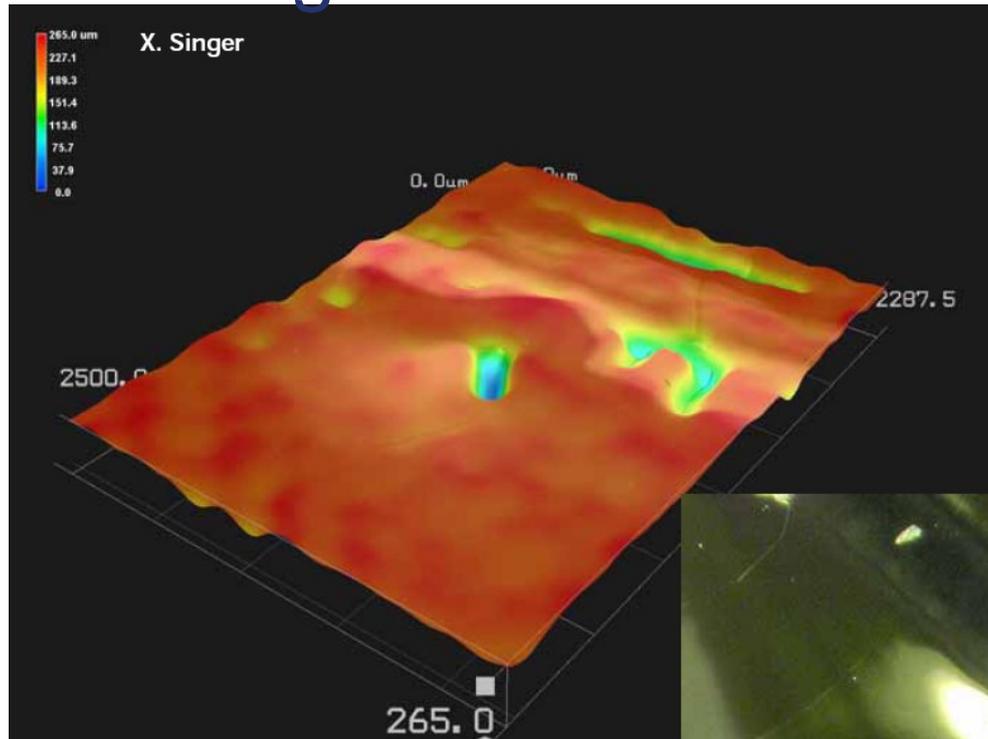


Z130: Quench in  $3\pi/9$ -mode at  
22 MV/m

Picture of same location

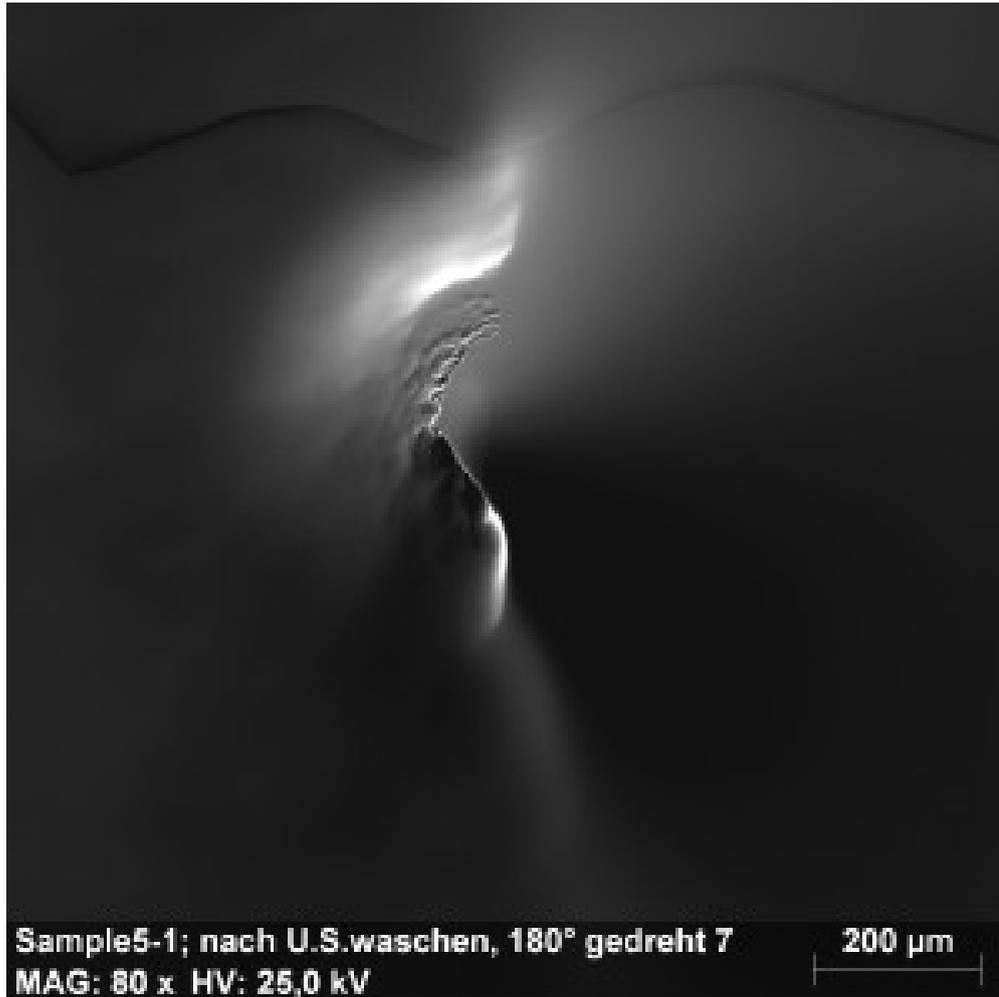
# Defect in Z130

- Cavity has been cut for further investigation
- EDX: no foreign material

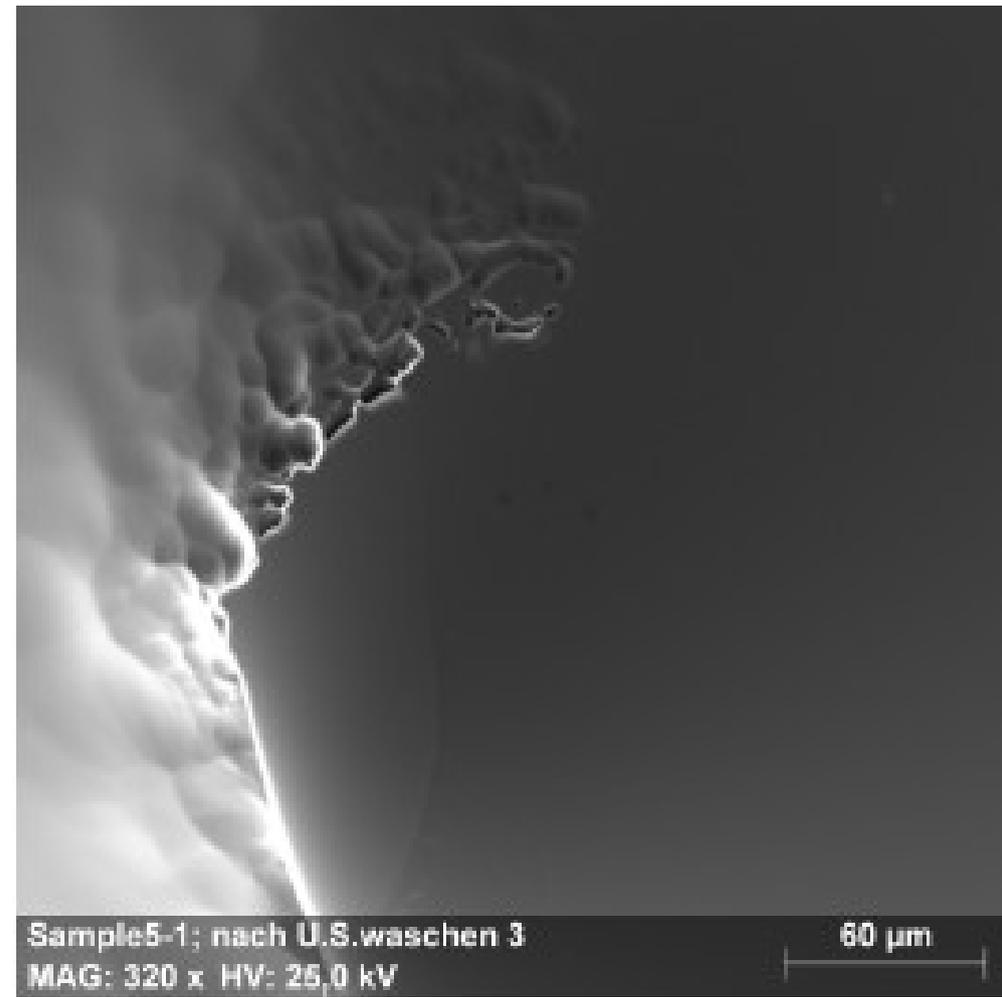


W. Singer, X. Singer, A. Ermakov

# SEM-Picture of the defect



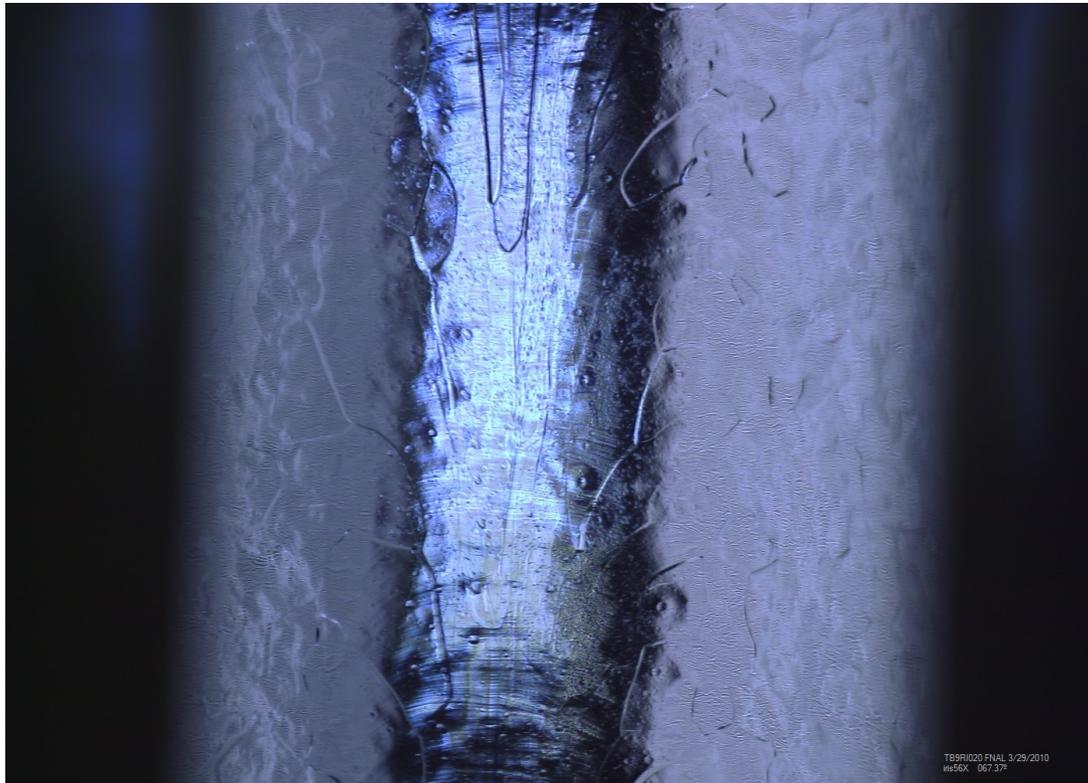
[D.Reschke]



Sharp ridges at edge of defect

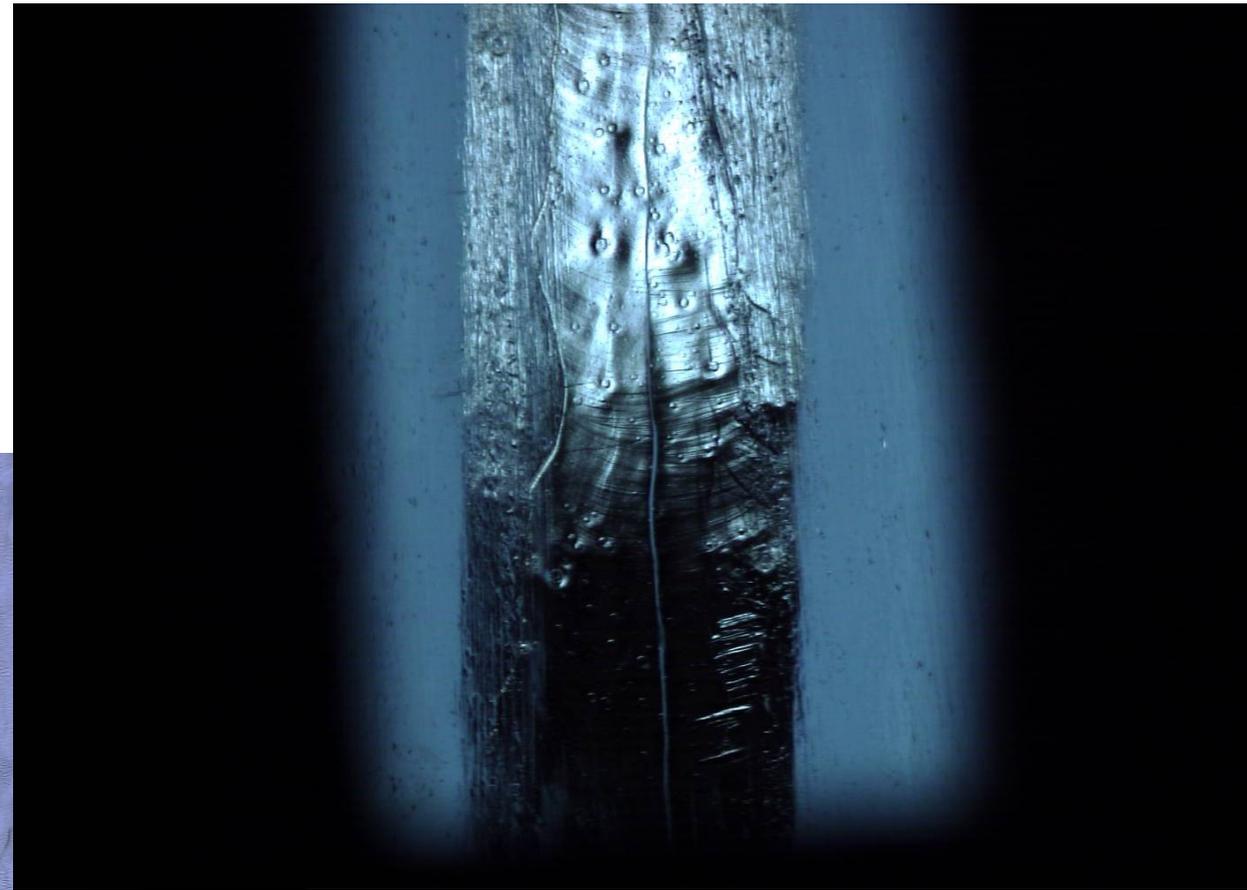
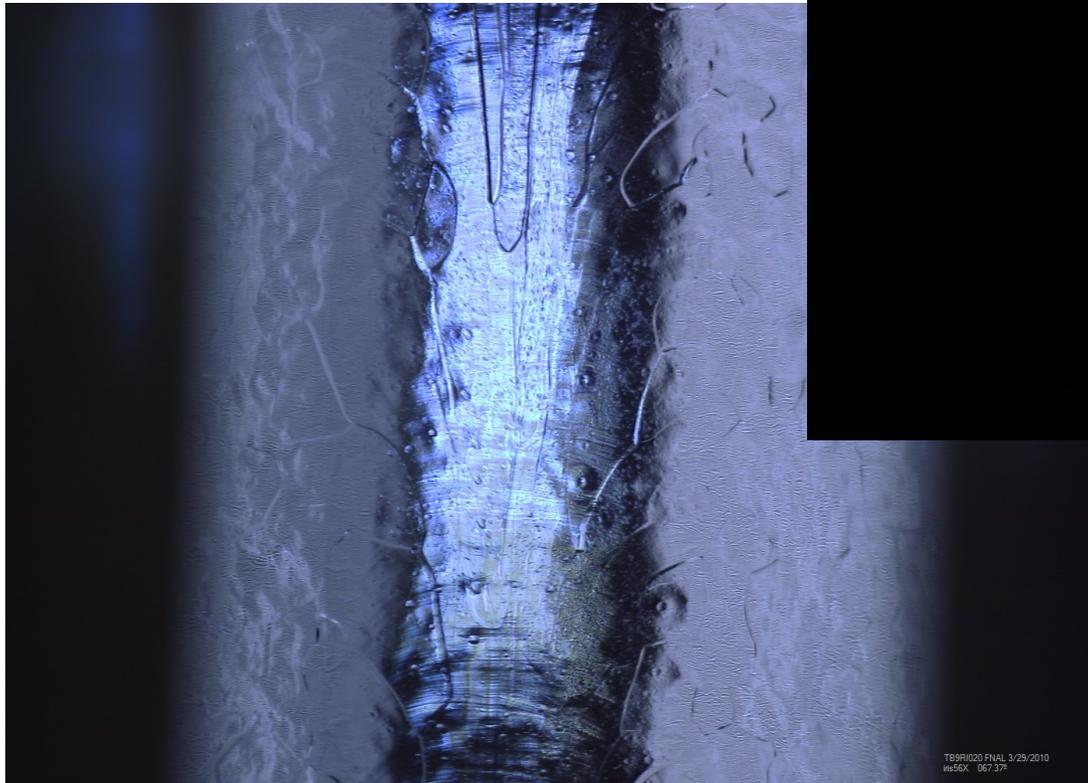
# Iris in „as received“ condition

FNAL: TB9RI020, iris 5-6



# Iris in „as received“ condition

FNAL: TB9RI020, iris 5-6



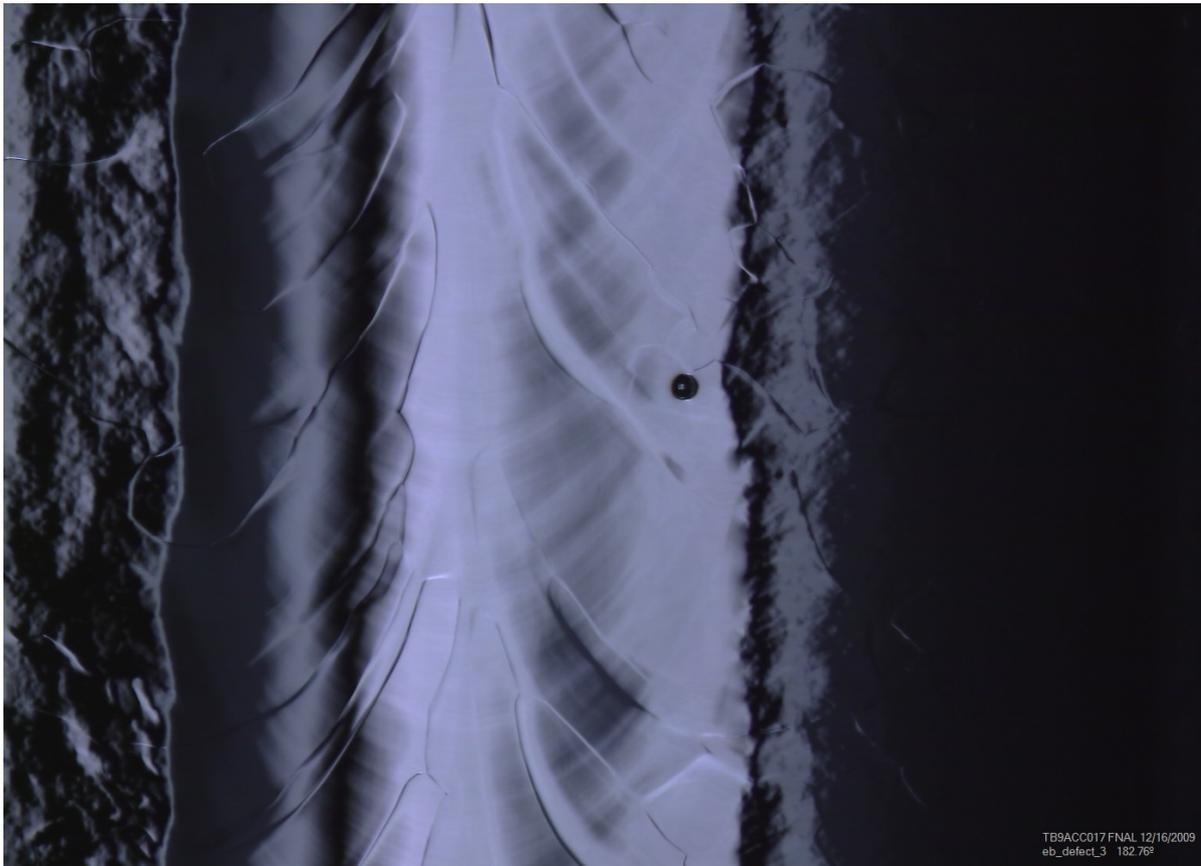
DESY: AC156, iris 3-4

„Pimples“ observed before  
chemical treatment

TB9RI020 FNAL 3/29/2010  
im56x 067.37

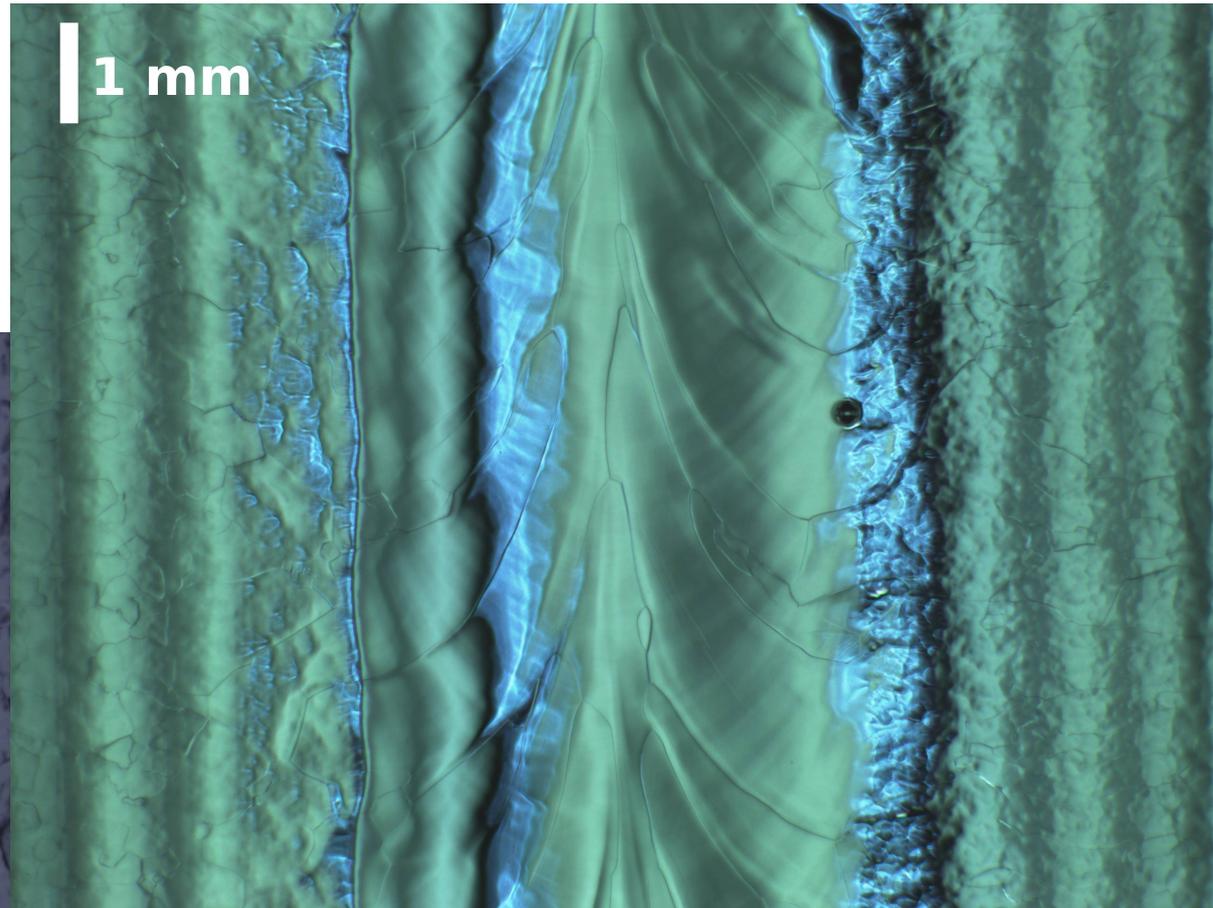
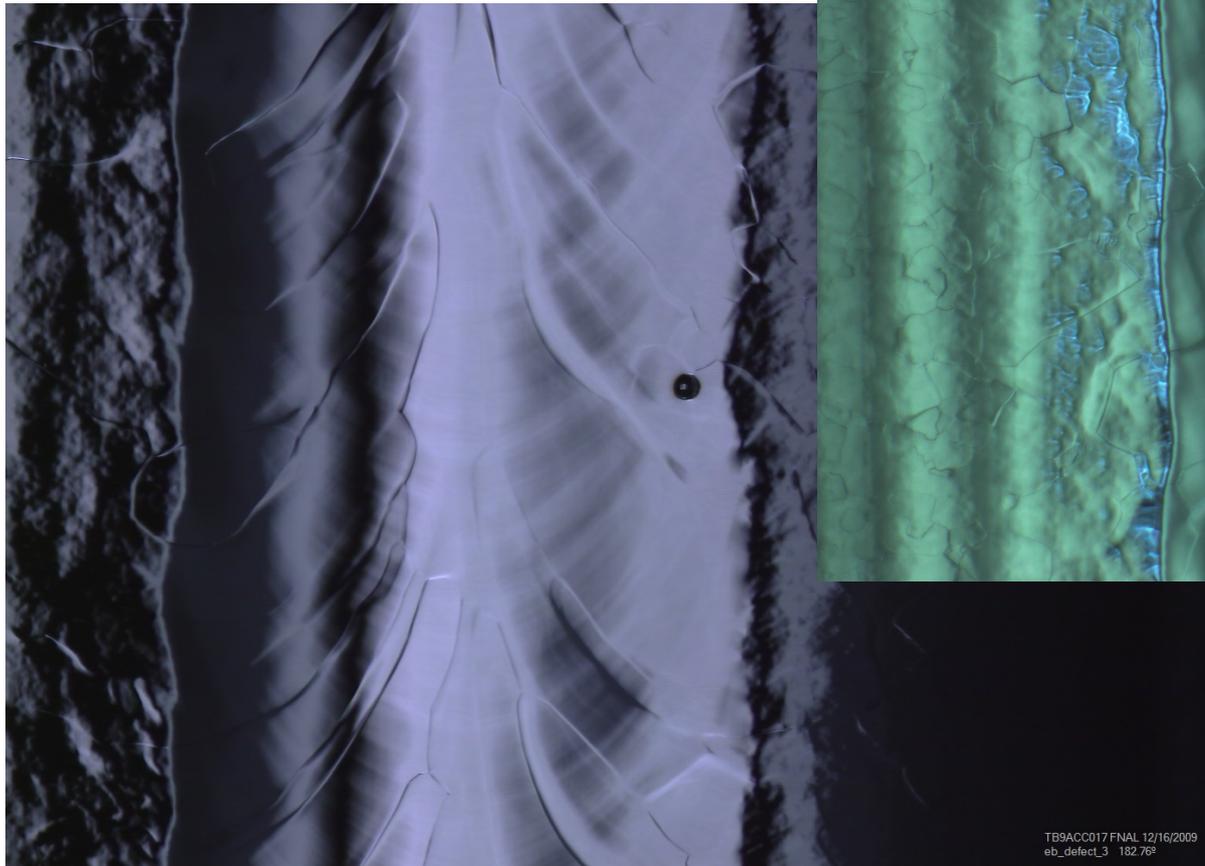
# Defects at edge of welding seam

FNAL: TB9ACC017,  
quench location



# Defects at edge of welding seam

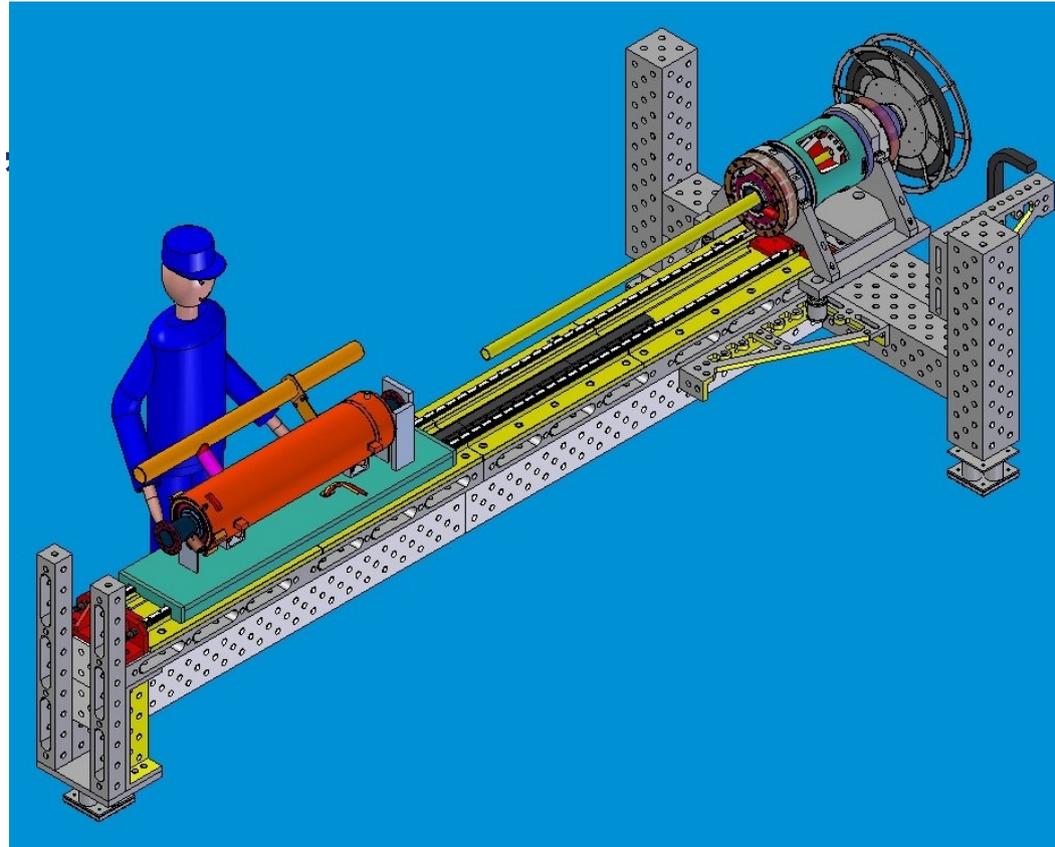
FNAL: TB9ACC017,  
quench location



DESY: AC120, no  
Tmap done yet

# Automated optical inspection

- Inspection of welding seams of a 9-cell cavity:
  - ~1500 pictures
  - „manual“ inspection takes up to 2 working-days
- Design of automated setup at DESY
- High precision positioning, high reproducibility
- High speed: ~2-3h/cavity
- Easy to operate
  - Possible application in production environment



# Summary

- Optical inspection in good use at labs around the world
- Increasing data-set of inspected cavities available
- KEK-analysis hints for shallow pits/broad bumps to be less harmful
- Inspection in consecutive preparation steps  
→ formation and evolution of defects
- „Pimples“ observed on some irises before chem. treatment
- Automation expected to speed up and facilitate inspection process
- Tendency for defects to sit on the edge of welding seam?
  - Possible explanations?